The IEEE 802.16 Working Group on Broadband Wireless Access Standards

Roger B. Marks
Chair, IEEE 802.16

National Wireless Electronic Systems Testbed
National Institute of Standards and Technology

Broadband Access

- The "Last Mile" (or the "First Mile")
  - Fast local connection to network
  - Data, voice, video

- Every customer wants it
  - Business
  - Residential

- Every operator wants it
  - Not just RBOCs/NBOCs & cable monopolies

Broadband Access for Big Business

- Fiber is nice

- But

  - Only 3-5% of 750,000 commercial buildings in U.S. have fiber

  - Backhoes don't follow Moore's Law

    - $150-250K per fiber mile to install

Broadband Access for Small Business/Residential

- **Cable Modems**

  - High infrastructure cost; slow rebuild

  - Shared bandwidth

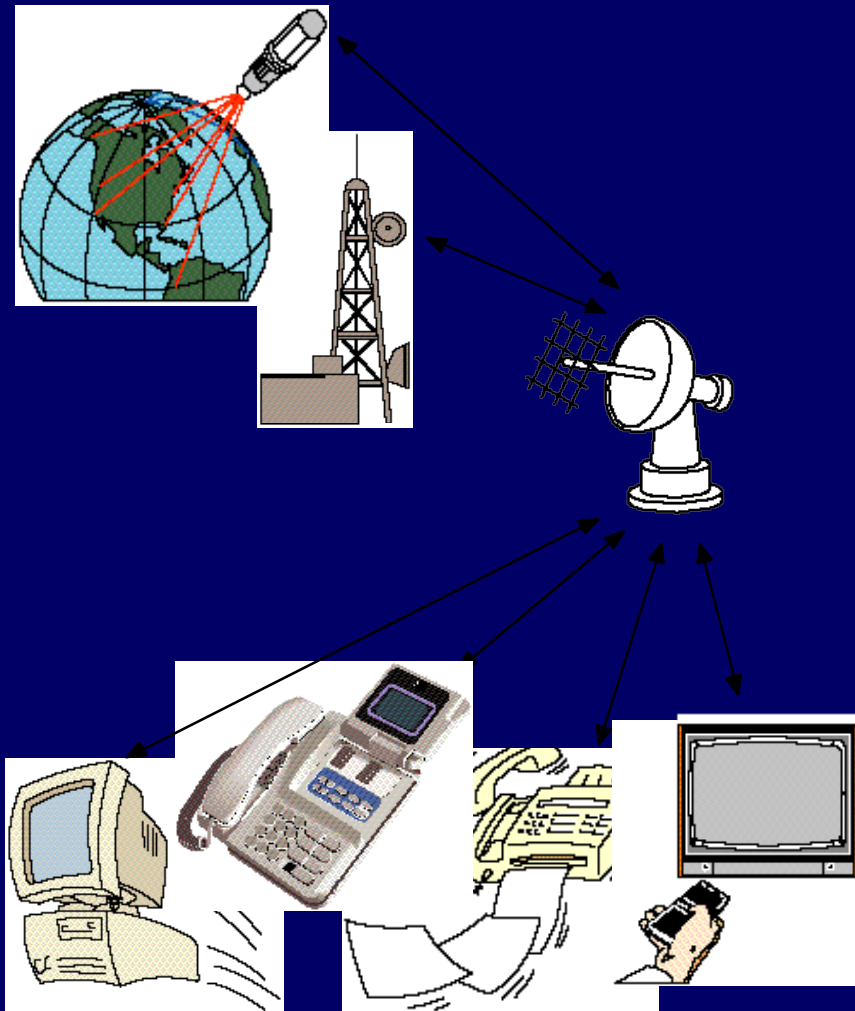- **DSL**

  - Infrastructure cost

  - Limited range

- **Satellite**

  - High up-front capital cost

Broadband Wireless Access (BWA)

–fixed (non-mobile) customer premises units

–base stations either:
  • fixed terrestrial
  • in orbit (LEO or GEO satellites)
  • in stratosphere (airplanes or blimps)

–broadband data into businesses, homes, etc.
  • ATM, TCP/IP, digital video, telephony

–potentially inexpensive and economically competitive with wired broadband

–Millimeter wave bands
  –U.S. spectrum auctions in '98 and '99
  –Largest spectrum in private hands
  –25 times as large as PCS spectrum cap

–Microwave (centimeter wave) bands
  –FCC allowing 2-way use
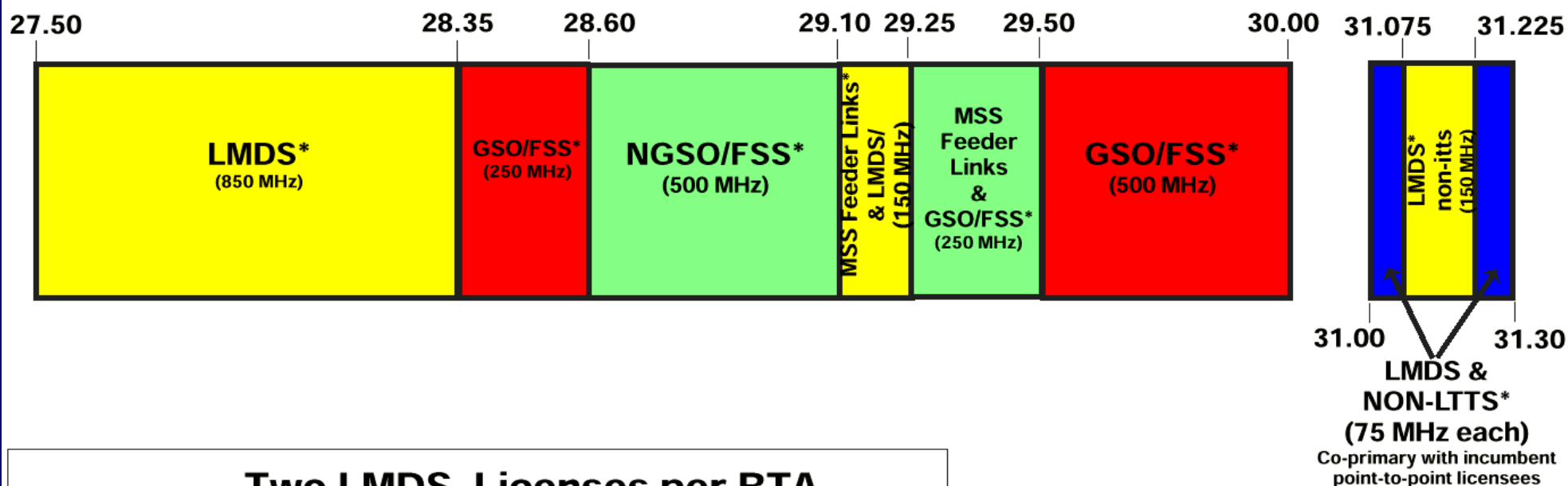
BWA Capacity

- **Hub radius: a few kilometers**

- **In each 50 MHz, at each hub:**

  - **3 Gbit/s**

  - **e.g. 64 customer sites at 45Mbit/sec each**

  - **up to 5000 sites/hub**

  - **(per WinStar)**

- **LMDS "A" Block is 23 times larger**

LMDS Band Allocation
(Local Multipoint Distribution Service)

28 & 31 GHz Band Plan

27.50		28.35	28.60		29.10	29.25	29.50		30.00	31.075		31.225

LMDS* (850 MHz)

GSO/FSS* (250 MHz)

NGSO/FSS* (500 MHz)

MSS Feeder Links/ & LMDS/ (150 MHz)

MSS Feeder Links & GSO/FSS* (250 MHz)

GSO/FSS* (500 MHz)

LMDS* non-itts (150 MHz)

31.00   31.30

LMDS & NON-LTTS* (75 MHz each)
Co-primary with incumbent point-to-point licensees

Two LMDS Licenses per BTA

Block A - 1150 MHz: (yellow)
27,500-28,350 MHz
29,100-29,250 MHz
31,075-31,225 MHz

Block B - 150 MHz: (blue)
31,000-31,075 MHz
31,225-31,300 MHz

Legend
"*" - Primary Service
FSS - Fixed Satellite Service
GSO - Geostationary Orbit
NON-LTTS - Non-Local Television Transmission Service
MSS - Mobile Satellite Service
NGSO - Non-Geostationary Orbit

Summary: WW Spectrum for BWA

Country	10 GHz ETSI	18-24 GHz	24 GHz DEMS	26 GHz ETSI	25-27 GHz	27.5-29.5 GHz	28 GHz Like US	31 GHz	38 GHz US	38 GHz ETSI	38 GHz Other
PMP Frequency Bands											
North America											
USA			X				X	X	X		
Canada			X		X		X		X		
Asia Pacific											
Australia							X	X			
Japan		X			XU						X
Korea					XU						
Malaysia	P										
New Zealand					X						
Philippines	X	X?			X		X				
Singapore						X?	X				
Taiwan				X							X
Thailand						X					
Central& South America											
Argentina	X		X		X		X	X	X		
Bolivia							X				
Brazil	P			P							
Chile					X		X				
Colombia					X		X				
Ecuador						X					
Mexico	X			X							
Paraguay						X					
Peru						X					
Venezuela						X					

CEPT Recommendation for Europe of 40.5-42.5 and 42.5-43.5 GHz not considered

Wireless Broadband Networks

Lucent Technologies
Bell Labs Innovations

Summary: WW Spectrum for BWA

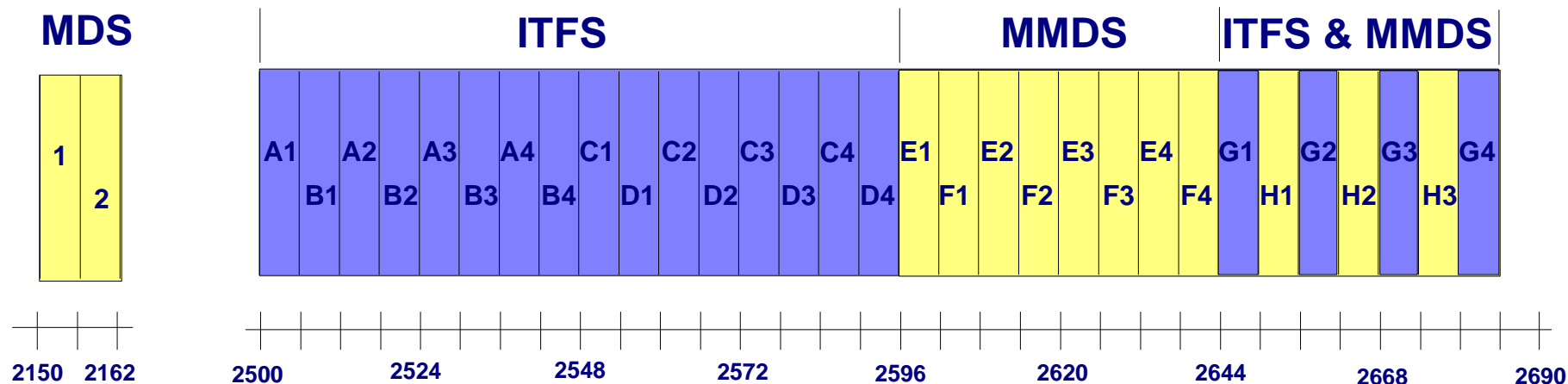| Country	PMP Frequency Bands										
	10 GHz ETSI	18-24 GHz	24 GHz DEMS	26 GHz ETSI	25-27 GHz	27.5-29.5 GHz	28 GHz Like US	31 GHz	38 GHz US	38 GHz ETSI	38 GHz Other
Europe, Middle East, Africa											
Czechoslovakia						X					
France						T					
Germany				X							
Hungary				X							
Ireland				X							
Israel				P?							
Netherlands				X							
Norway				X							
Poland						X					
Romania							X				
South Africa						X					
Spain				X			X	X			
United Kingdom	X										

CEPT Recommendation for Europe of 40.5-42.5 and 42.5-43.5 GHz not considered

3

MMDS & ITFS

MDS
(MDS, MMDS, ITFS, Services)

MDS | **ITFS** | **MMDS** | **ITFS & MMDS**

MDS channels: 1, 2 (2150–2162)

ITFS/MMDS channels: A1, B1, A2, B2, A3, B3, A4, B4, C1, D1, C2, D2, C3, D3, C4, D4, E1, F1, E2, F2, E3, F3, E4, F4, G1, H1, G2, H2, G3, H3, G4

Frequency scale (MHz): 2500, 2524, 2548, 2572, 2596, 2620, 2644, 2668, 2690

Congressional Federal Register References

ITFS	47 C.F.R., Part 74
MDS (Single And Multichannel)	47 C.F.R., Part 21

Channel 2A: 2156-2160 MHz

2160-2162 MHZ reallocated to emerging technologies on a primary basis except for licenses operating on Channel 2, or successful applicants who filed prior to January 16, 1992. See ET Docket 92-9 FCC 93-351

MDS (Multipoint Distribution Service)
MMDS (Multichannel Multipoint Distribution Service)
ITFS (Instructional Television Fixed Service)

Service		Channel Allocation	Number of Channels
	MDS & MMDS	1 & 2	2
		E, F & H	11

Not Included in Auction #6

Service		Channel Allocation	Number of Channels
	ITFS	A, B, C, D & F	20

UNII
esp. 5.25-5.35 & 5.725-5.825 GHz

Market Guess from 1998

Broadband Subscribers by Technology, US Market, 2003

- Others 5%
- Satellite 12%
- LMDS 9%
- ISDN 12%
- Cable Modem 26%
- ADSL 36%
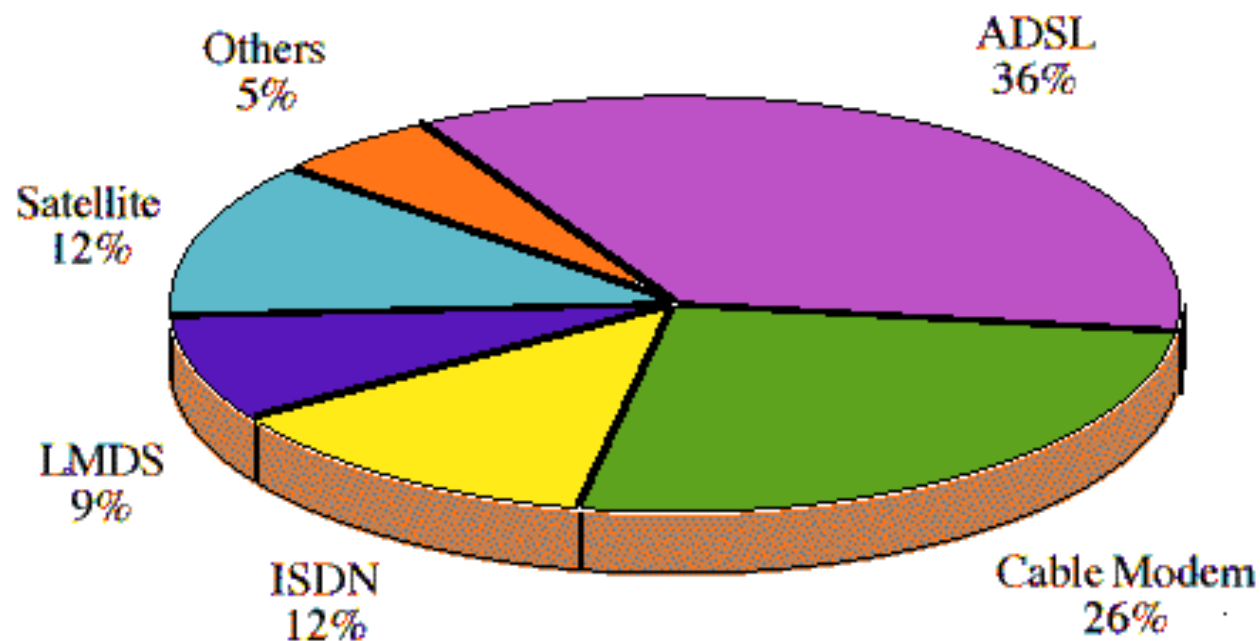
Source: Allied Business Intelligence, Inc.

Shipments of Millimeter Wave Systems*, World Market, 1998
Auto Collision, LMDS, Satellite
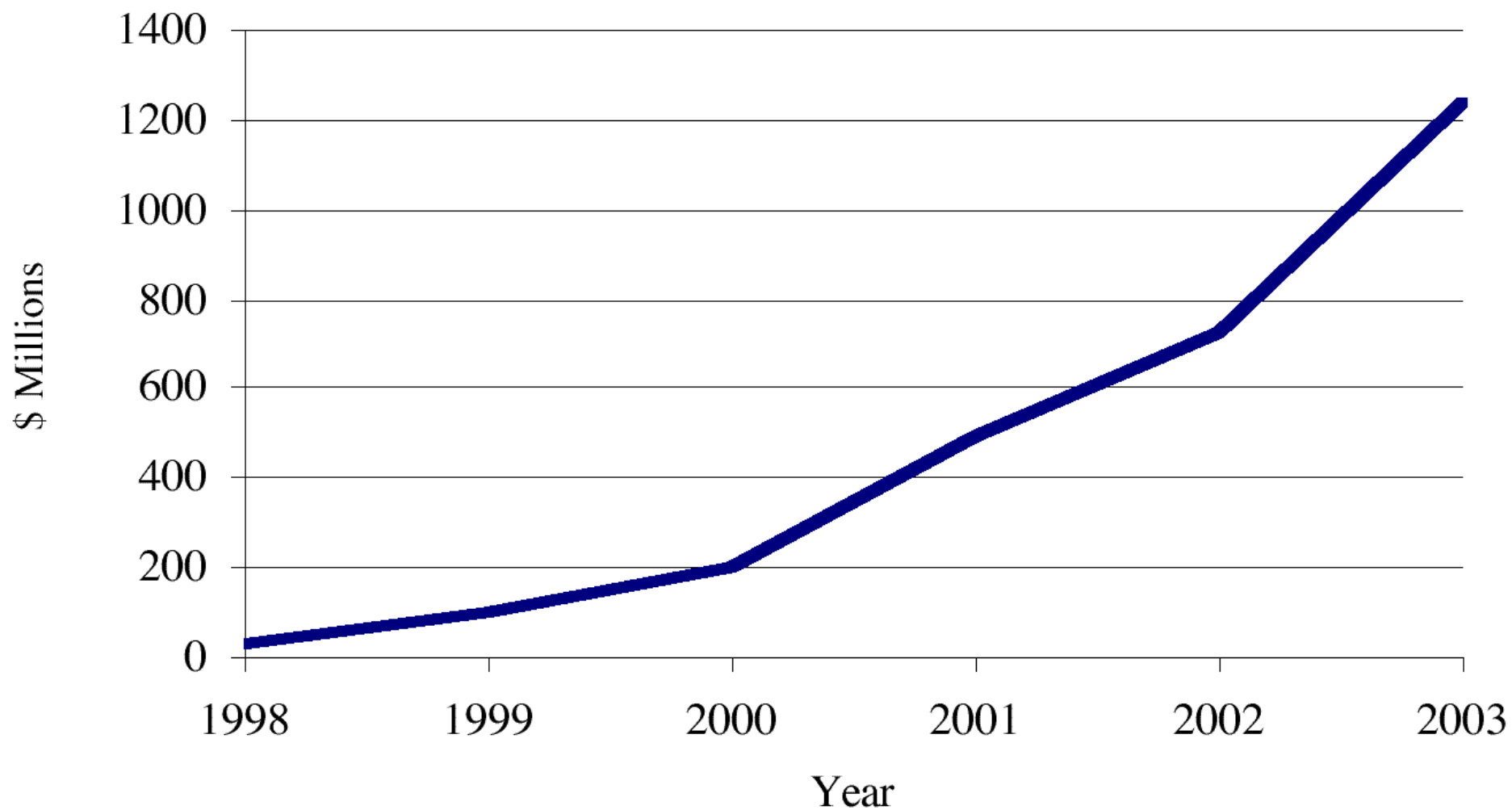
Source: Allied Business Intelligence, Inc.

*Point-to-Point Microwave not included

Major U.S. License Holders

- **Millimeter wave (24, 28, 31,38 GHz)**
  - NextLink
  - ART
  - WinStar
  - Teligent
  - Many smaller players

- **Microwave (2.5-2.7 GHz) [MMDS, ITFS]**
  - MCI WorldCom
  - Sprint
  - Many, many smaller players

Why Standards?

Survey Tuesday (6 March 2000) of about 600 people at BW World Forum:

How important are standards to the long-term success of this industry?

Extremely important: 59%

Somewhat important: 30%

Business Case for Broadband Wireless Standards

"Subassembly and chip manufacturers simply cannot supply the performance ... at a price which is feasible for significant penetration into the consumer market today... LMDS may be closest to achieving this goal, but its *lack of a unified standard and lack of commitment to significant volumes will inhibit further price declines.*"

- "Millimeter Wave 1998" Allied Business Intelligence

Wireless Standards in the United States

- FCC no longer regulates standards for wireless communications (spectrum auctions since 1994)

- no coordinated U.S. approach to wireless standardization

- standardization in newly-auctioned spectrum is slow

- multiple standards continue indefinitely

- equipment costs remain high

- for new services, licensees and vendors may hesitate

N-WEST is:

- a measurement testbed at the Department of Commerce to help forge industry consensus standards and specifications

- a pro-active effort to accelerate development of the broadband wireless industry by encouraging voluntary standards

N-WEST Philosophy

Goal: Accelerated Commercialization of Wireless Systems

equipment cost reduction (esp. at customer end)

mass production

standardization

voluntary standards bodies (IEEE)

unbiased measurement support

U.S. Dept. of Commerce

Initial Focus: Broadband Wireless Access

81 N-WEST Supporting Companies

- Industry Associations
  - Cellular Tel. Ind. Assn. (CTIA)
  - Wireless Comms Assn. (WCAI)
- License Holders
  - Antilles Wireless Cable TV Co.
  - Charles Brinkman
  - Formus Communications, Inc.
  - US WEST Adv. Technologies
  - Virginia Tech
  - Teligent, Inc.
  - WinStar Communications, Inc.
  - WNP Communications, Inc.
- Systems Equipment Providers
  - 3Com Corporation
  - ADC Telecommunications
  - Alcatel Network Systems
  - Adaptive Broadband, Inc.
  - Belstar Systems Corp.
  - ComTier, Inc.
  - Ensemble Communications
  - Ericsson Inc.
  - Intraplex
  - ioWave, Inc.
  - Lucent Technologies
  - Motorola Inc.
  - NEC America, Inc.
  - Netro Corpopration
  - Newbridge Networks Corp.
  - Nortel Networks
  - P–COM
  - Philips Broadband Networks

- Spike Technologies, Inc.
  - WaveCom Electronics Inc.
  - WaveSpan Corporation
  - Wavtrace
  - WinNet MCS
  - Wytec Inc.
- Subsystems and Components
  - AMP M/A–COM
  - Andrew Corp.
  - Asvan Technology LLC
  - BroadBand Wireless Inc.
  - Cable AML Inc.
  - CircuitPath Network Systems
  - EER Systems
  - Endgate Corporation
  - ETM Electromatic
  - Gigabit Wireless Inc.
  - Hewlett-Packard Co.
  - IDT Inc.
  - Integrity Communications
  - ITS Electronics, Inc.
  - MentorData Ltd.
  - Micro Interconnect, Inc.
  - Millitech Corporation
  - Mitsubishi Electronics America
  - MMCOMM, Inc.
  - Phasecom Inc.
  - Raychem Corp.

- Raytheon Systems Company
  - Run.com Communications Ltd.
  - SiCOM, Inc.
  - Siemens Microelectronics, Inc.
  - Stanford Wireless Broadband Inc.
  - TelesciCOM Ltd.
- RF Semiconductors
  - Fujitsu Compound Semiconductor
  - Harris Semiconductor
  - Sanders, A Lockheed Martin Co.
- Consultants/R&D/Measurements/Misc.
  - Anritsu Company
  - Bellcore
  - C&W Systems, Ltd.
  - E B Systems Limited
  - EDX Engineering, Inc.
  - ETRI
  - Gerson Lehrman Group
  - Hardin & Associates, Inc.
  - HRL Laboratories
  - Illinois Institute of Technology
  - Istari Design, Inc.
  - LCC International Inc.
  - MLJ, Inc.
  - PSW Technologies, Inc.
  - Technical Strategy Associates
  - WFI
  - Wireless Valley Communications, Inc.

Standardization Body

IEEE

- IEEE Standards Association
  - IEEE 802.16

- **802.16 Sponsorship**
  - IEEE Computer Society
    - IEEE 802: LAN/MAN Standards Committee

  - IEEE Microwave Theory & Techniques Society

IEEE 802
The LAN/MAN Standards Committee

Wired:

– **802.3 (Ethernet)**

Wireless:

– **802.11: Wireless LAN**

  • **Local Area Networks**

– **802.15: Wireless PAN**

  • **Personal Area Networks {inc. Bluetooth}**

– **802.16: WirelessMAN™**

  • **Metropolitan Area Networks**

Why IEEE 802?

Telecom Standardization

- National

- Political

Datacom Standardization

- Global

- Open

- Industry-Driven

- 802 and IETF set the standards

Who are the Members?

- **Telecom Standardization Bodies**
  - Governmental Representatives
  - Companies

- **IEEE**
  - engineers

802's Success

802.3: Ethernet (10/100/1000BaseT)

- **4Q98 sales**
  - **$2.3 billion of Ethernet switching**
    - **excludes routers and nodes**
    - **supports 30 million connections**
  - **13.5 million 100BaseT Nodes (NICs, etc.)**

- **reference: Dell'Oro Group**

Process

- **Task Groups**

- **Call for Contributions**

  – **Specific topics for discussion at next meeting**

- **Receive and post written contributions**

- **Discuss and debate at meeting**

- **Create draft by 75% vote**

- **Finalized through open "Sponsor Ballot"**

N-WEST/802.16 History in Brief Part 1

- April 3, 1998
    - N–WEST Web Site went on–line (http://nwest.nist.gov)
- July 24, 1998
    - Strategy Session (10 people)
- August 9-10, 1998
    - Kickoff Meeting (45 people)
- August 9-12, 1998
    - 1998 IEEE Radio and Wireless Conference (RAWCON'98) attended by 300 people
- November 9-10, 1998
    - Second meeting, at IEEE 802 Plenary (41 people)
    - 802 approved the

        802 Executive Committee Study Group on BWA

Wireless camps' goal: affordable systems

Open-systems push sweeps broadband

By Loring Wirbel

COLORADO SPRINGS, COLO. — Hustling to infuse life into a market perceived as pricey and arcane, proponents of broadband wireless services came to the IEEE Radio & Wireless Conference (Rawcon) last week with strategies for pushing standardization and, by extension, lower-cost, more-accessible systems.

Proponents of millimeter-wave broadband systems are still smarting from the lukewarm response to the FCC's 28-GHz auctions, which raised a less-than-stellar $570 million from a smaller-than-expected pool of carriers. In a lunch address at Rawcon, National Telecommunication & Information Administration head Larry

N-West's Marks: Nod for NIST as 'facilitator.'

Irving told local multipoint distribution service (LMDS) developers that they are perhaps the last great hope for "last-mile" broadband services. But much is riding on their ability to get the cost out of their systems.

"I have seven separate wireless systems in my household, but I'm still stuck with 56k in my wireline service," Irving said. "If we had 'calling party pays,' I'd give up my wireline phone completely tomorrow, because you guys will be giving me broadband data service a lot faster than my wireline phone company."

A new report from Allied Business Intelligence (Oyster Bay, N.Y.) states that the mul-

Standards efforts from Europe, Japan and U.S. coalesce around gigahertz networks

Groups eye unified broadband wireless specs

By Loring Wirbel

ORLANDO, FLA. — Developers took the crucial first steps last week in synchronizing global standards for all broadband wireless systems, from 5 GHz to 50 GHz and beyond, as standards bodies from the United States, Europe and Japan convened here. While strong differences of opinion persist over physical interfaces and data-link structures, the meeting advanced the goal of a common infrastructure between in-building wireless LANs and new, micro- and millimeter-wave broadband networks with a cellular-like infrastructure.

Wide-area schemes showed the strongest signs of convergence, though some wrinkles must be ironed out. Among local-area networks, separate U.S. and European wireless offerings continue to resist harmonization, and a nascent class of "personal-area" wireless links still occupies a relatively undefined spot at the fringes of interoperability.

The IEEE's 802.11 wireless-LAN working group and

GRABBING THE GHz WAVE

N-WEST/802.16 History in Brief Part 2

- January 13-15, 1999
  - First Study Group meeting (66 people)
  - Joint with IEEE 802.11 and ETSI BRAN
  - Wrote project plan (PAR): interoperable air interface
- March 9-11, 1999
  - Met with 802 Plenary (54 people)
  - Working Group 802.16 created
  - Finalized air interface PAR (802.16.1)
- May 10-12, 1999
  - 802.16 Session #0 (55 people)

802.16 Session History

IEEE 802.16 Sessions (1 week each):

- **#1: July 1999: 106 people became members**
  - –Finalized coexistence PAR (802.16.2)
- **#2: August 1999: Functional Requirements**
- **#3: September 1999: Developed Schedule/Process**
- **#4: November 1999**
  - –heard 802.16.1 Proposals (19 PHY, 15 MAC)
  - –Created Sub10 Study Group (<10 GHz)
- **#5: January 2000 (118 people)**
  - –heard 2 Converged 802.16.1 Proposals
  - –Developed Sub10 plan

802.16 Session History (cont.)

#6: Mar. 6-9, 2000, Albuquerque (126 people)

- Two 802.16.1 proposals refined
- 802.16.3 group established
- Wireless High-Speed Unlicensed MAN (WirelessHUMAN™)

#7: May 1-5, 2000, DC (158 people)

- Selected 802.16.1 PHY proposal
- Plan for merged 802.16.1 MAC proposal
- First 802.16.3 meeting (requirements)
- First WirelessHUMAN™ meeting
- agreement with ETSI BRAN

802.16 Meeting Schedule

#7.5: May 30-June 2, 2000, Boulder, CO

- Detailed Outline of 802.16.1 MAC proposal
- PHY and MAC Modeling

#8: July 10-13, 2000, La Jolla

- 802.16.1 moves to letter ballot stage

#9: September 11-15, 2000, Denver

- Revisions of 802.16.1 draft

#10: November 6-10, 2000, Tampa

- 802.16.1 draft completed
- 802.16.2 draft completed

802.16 Leaders

- Chair: Roger Marks, NIST

- Vice Chair: Lou Olsen, Teligent

- Secretary: Scott Marin, Spectrapoint

- Functional Requirements
  - George Fishel (consultant)
  - Brian Petry, 3Com

802.16 Projects

802.16.1: Air Interface, 10-66 GHz

- PHY Chair: Jay Klein, Ensemble
- PHY Editor: Jeff Foerster, Newbridge
- MAC Chair: Carl Eklund, Nokia

802.16.2: Coexistence

- Leland Langston, Crosspan (Chair)

802.16.3: Air Interface, 2-11 GHz (licensed)

- Brian Kiernan, Interdigital (Chair)
    - Carl Bushue, Sprint (Vice Chair)

Wireless High-Speed Unlicensed MAN (study)

- WirelessHUMAN™
- Durga P. Satapathy, Sprint (Chair)

Current 802.16.1 Proposal

Backed by 35 participants from:

3Com

Adaptive Broadband Inc.

BreezeCOM

CircuitPath Network Systems

Communications Consulting
 Services

Crosspan (A Raytheon Co.)

Digital Microwave
 Corporation

Ensemble Communications

Ericsson

iSKY

Lucent

Motorola

Newbridge

Nokia

Nortel

Oren Semiconductor Ltd.

SiCOM, Inc.

Siemens

Spacebridge Networks Corp.

SpectraPoint

TelesciCOM Ltd.

Vyyo

802.16 Press Coverage

- *Telecommunications* magazine (May 2000) chose "The 10 Hottest Technologies"

- Time Division Duplexing

- LMDS: "less-than-widespread deployment"

- "Air interface standards, currently being worked on in the IEEE's 802.16 committee to deal with issues such as interference and interoperability, could help change that, propelling broadband wireless to a $7.4 billion market for services by 2003, according to the Strategis Group."

Resources

Web Site

http://wirelessman.org

(http://ieee802.org/16)

230,000 downloads in May 2000

email reflector

~400 subscribers

archived

N-WEST News

http://nwest.nist.gov

~850 subscribers

How to Participate

- Attend meetings

- Read reflector

- Read documents

- Submit documents & comments

- Join sponsor ballot pool

Sponsor Ballot

- **Any member of IEEE Standards Association may vote on draft standards**
  - IEEE-SA costs $10 on top of IEEE membership
- **Great opportunity**
  - Influence important results
  - Free access to valuable documents
- **For IEEE 802.16, sign up at**

  ## http://wirelessman.org